Title of Investigation:

Can a Yb:KYW-based Laser Replace Nd:YAG as the 1-µm Gain Medium of Choice in LIDAR and Laser Altimetry?

Principal Investigator:

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Other Investigators/Collaborators:

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Initiation Year:
FY 2003

Aggregate Amount of Funding Authorized in FY 2003 and Earlier Years:

$39,000

FY 2004 Authorized Funding:

$39,000

Actual or Expected Expenditure of FY 2004 Funding:

$8,000 to Thales for 980-nm diodes; $2,500 to Eksma for Yb:KYW crystals; $8,000 to Onyx Optics for slab bonding; $2,500 to Twinstar for slab coatings; $2,500 to CVI for laser optics; $1,500 to Cleveland Crystals for Q-switch; $9,000 for laser electronics; and $5,000 for drawings and machine shop.

Status of Investigation at End of FY 2004:

To be continued through January 2005 with remaining FY 2004 funds.

Purpose of Investigation:
Currently, most 1-µm light-detection and ranging systems (LIDARs) use NeodyniumYittrium Aluminum Garnet (Nd:YAG) crystals as their laser medium. Even though Nd:YAG has provided reasonably good results in output and thermal control in the past, we believe the use of an alternative medium—Ytterbium: Tungstate (Yb:KYW)—could improve performance, particularly if it were pumped with 980 nm of InGaAs diodes. We intend to build a simple Yb:KYW-based laser cavity for demonstration purposes, taking advantage of recent advances in 980-nm diode laser technology. Through this effort, we hope to provide NASA with a more reliable and efficient 1-µm laser source, which will improve optical efficiencies by about 20% and prove more reliable than similar Nd:YAG-based systems.

FY 2004 Accomplishments:

Our first accomplishment was designing a laser slab and a reasonable method to pump it with linear 980-nm diode arrays. To our knowledge, all oscillator designs using Yb:KYW as a lasing medium have been of the end-pumped, thin-disc configuration. This end-pumped method helps minimize the losses inherent to Yb-doped hosts, but does not offer the power scalability available to side-pumped systems. Unfortunately, side pumping typically requires very high pump power densities to operate efficiently. Our composite slab design, shown in Figure 1, makes side pumping possible at relatively low pump powers by taking advantage of the high-absorption cross-section of Yb:KYW. We will use a lens duct constructed from gold-plated mirrors to compress and deliver the highly divergent diode light into the composite slab.

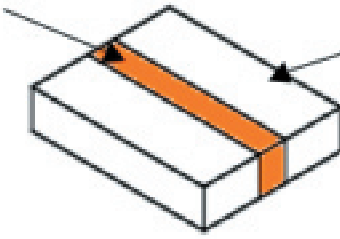

Figure 1. This unique design combines two pieces of un-doped KYW crystals, sandwiched between a Yb-doped KYW crystal.

We also have received and characterized the 980-nm diode. The characterization involves inspection under our high-power microscope to search for any obvious defects. Next, we imaged the diodes firing under low current and completed a power-versus-operating current curve to compare results with the manufacturers specifications. The imaged diodes can be seen in Figure 2. Furthermore, all the laser-head components have been designed and are in fabrication.

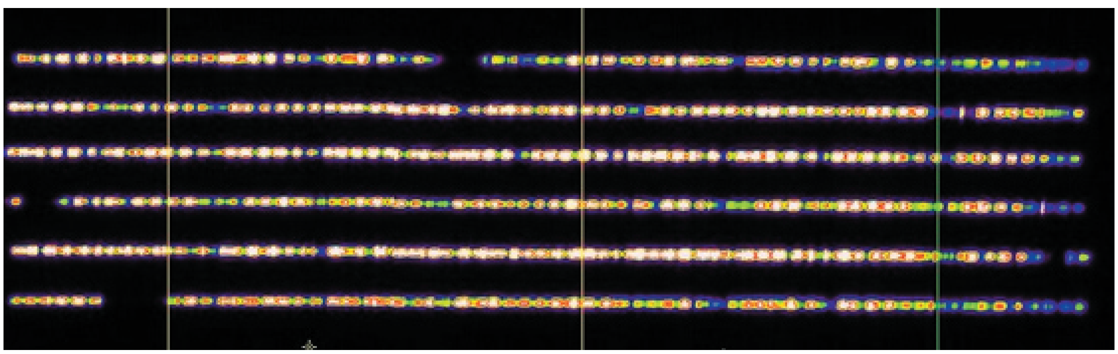

Figure 2. Using a carefully lensed and filtered camera and using our custom-designed data/imaging system, we can actually view the emitters on the diode array firing at a low repetition rate and power. Though some of the individual emitters are out, we do not believe this will significantly reduce the diode's power output.

Planned Future Work:

We are scheduled to complete final fabrication of the laser slab in early 2005. This involves bonding the Yb-doped portions of the slab with the un-doped portions and then applying anti-reflection and high-reflection coatings. Once they are received, and in-house inspections are completed, we intend to assemble the laser cavity and optimize the laser for thermal control and output quality in a long-pulse configuration. By February 2005, we plan to Q-switch the system and optimize its performance. In parallel, we also plan to upgrade our current scheme of controlling the temperature of the 980-nm diode with a thermoelectric cooler to increase the optical efficiency of our system. After we are satisfied with the performance of this particular system, we will publish the results. With the hope of obtaining more funding, we will use the lessons learned from this project to upgrade the design.

Summary:

To date, this is the only design we know of that attempts to side pump an Yb:KYW laser slab, rather than using an end-pumped thin disc. We also believe this is one of the first efforts to research Yb:KYW materials, pumped with the InGaAs diodes, for eventual use in laser altimetry to determine the elevation of objects. Building a laser resonator using a 980-nm-pumped Yb:

KYW crystal as an alternative to 810-nm-pumped Nd:YAG systems could lead to more efficient and reliable LIDAR designs. The technology also could boost the repetition rate (data volume) and improve thermal cooling (deployment cost). This project will be successful if we can fully characterize the laser firing and then apply the data to a new and improved design. Obtaining high-quality slab coatings and designing an efficient way to focus the diode light into the slab so that it will operate properly is a major challenge, whose risk was the main justification for the program. When the components finally arrive, it will be assembled, characterized and published in a refereed publication.